

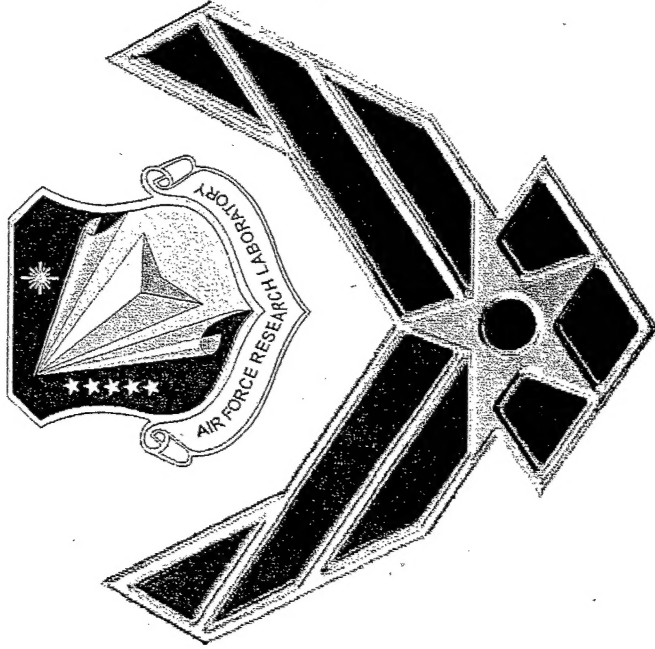
# REPORT DOCUMENTATION PAGE

Form Approved  
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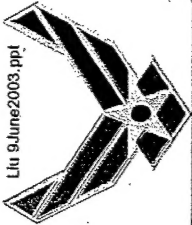
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<b>1. REPORT DATE (DD-MM-YYYY)</b> 16-06-2003		<b>2. REPORT TYPE</b> Technical Viewgraph Presentation		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b>  The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion				<b>5a. CONTRACT NUMBER</b>	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b>	
<b>6. AUTHOR(S)</b>  C.T. Liu				<b>5d. PROJECT NUMBER</b> 2302	
				<b>5e. TASK NUMBER</b> 0378	
				<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>  Air Force Research Laboratory (AFMC) AFRL/PRSM 10 East Saturn Blvd. Edwards AFB CA 93524-7680				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  AFRL-PR-ED-VG-2003-160	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>  Air Force Research Laboratory (AFMC) AFRL/PRS 5 Pollux Drive Edwards AFB CA 93524-7048				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>	
				<b>11. SPONSOR/MONITOR'S NUMBER(S)</b> AFRL-PR-ED-VG-2003-160	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b>  Approved for public release; distribution unlimited.					
<b>13. SUPPLEMENTARY NOTES</b>  For presentation at the ASME Pressure Vessel Conference in Cleveland, OH, 21-25 July 2003.					
<b>14. ABSTRACT</b>					
<b>20030812 148</b>					
<b>15. SUBJECT TERMS</b>					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified	A	17	Leilani Richardson
					<b>19b. TELEPHONE NUMBER (include area code)</b> (661) 275-5015

# **The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion**



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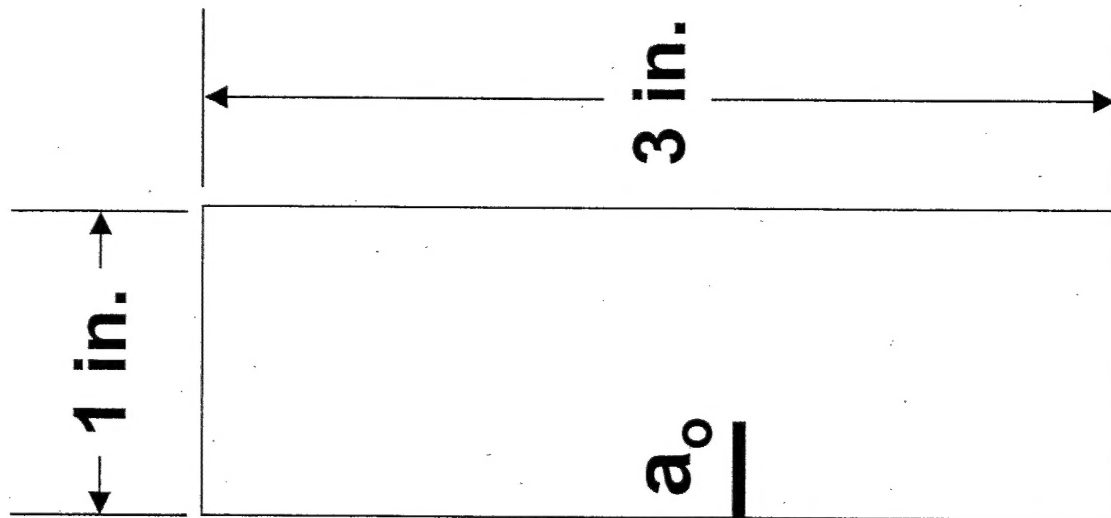
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# Objectives:



- Determine the Inherent Critical Initial Crack Size in a Particulate Composite Material for Developing an Inspection Criterion.
- Determine the Statistical Distribution Function of the Inherent Critical Crack Size.

# Specimen Geometry



$$\begin{aligned} a_o &= 0.0 \text{ in.} \\ &= 0.1 \text{ in.} \\ &= 0.2 \text{ in.} \\ &= 0.3 \text{ in.} \end{aligned}$$



# Crack Growth Equations



$$K_I = \sigma (\pi a)^{1/2} f(a/w)$$

$$f(a/w) = 0.77722(a/w)^3 + 0.9253(a/w)^2 + 1.095(a/w) + 1.005$$

$$K_{IC} = \sigma_c (\pi a_c)^{1/2} f(a_c/w)$$

$$da/dt = Q K_I^m$$



# Statistical Distribution Functions



$$F_X(x) = \Phi\left(\frac{x - u}{\sigma}\right)$$

**Normal Distribution**

$$F_X(x) = \Phi\left(\frac{\ln x - u^*}{\sigma^*}\right)$$

**Lognormal Distribution**

$$F_X(x) = 1 - \exp\left[-(x/\beta)^\alpha\right]$$

**Two-Parameter Weibull Distribution**

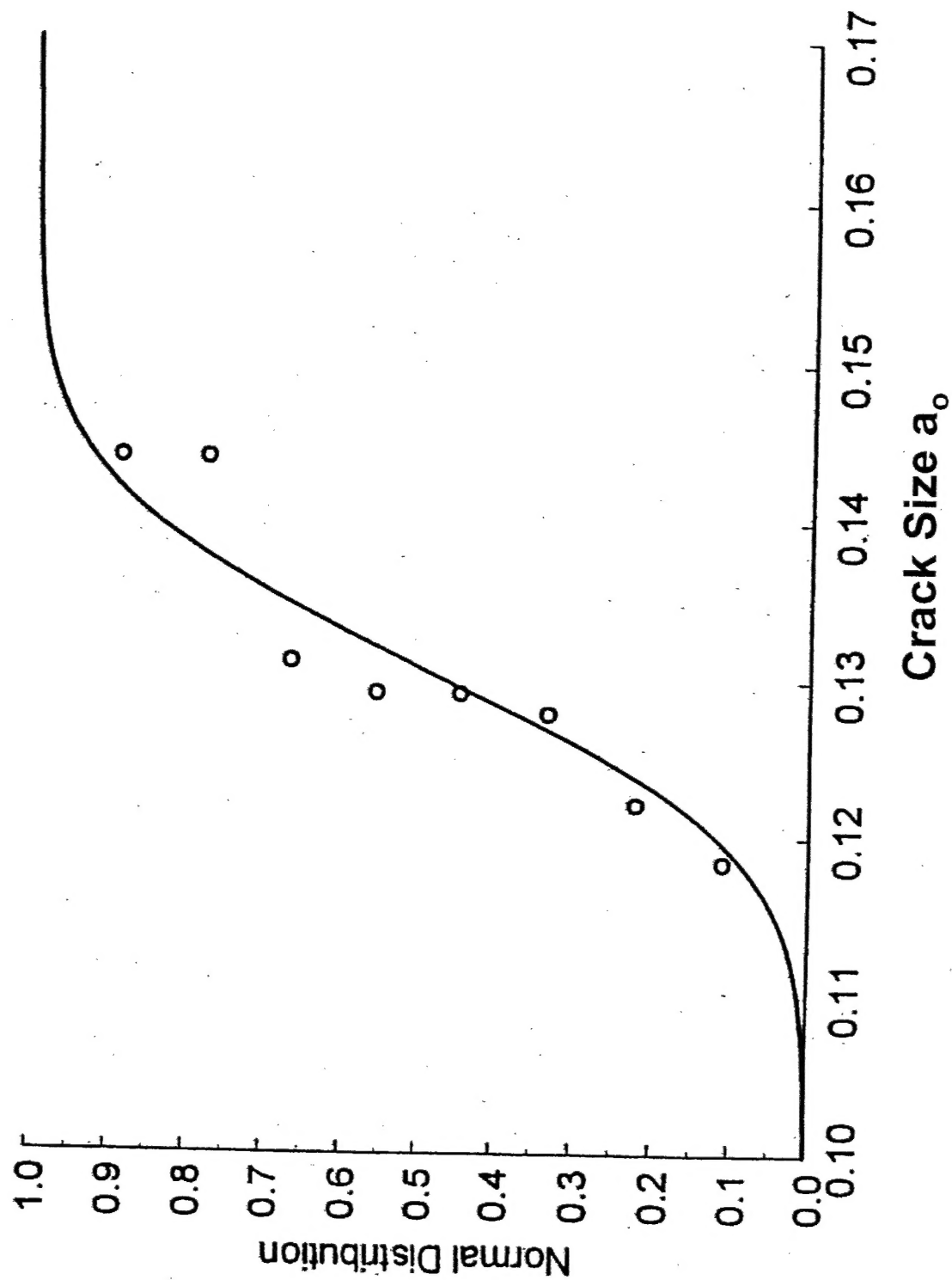
$$F_X(x) = \exp\left[-(x/v)^{-\kappa}\right]$$

**Second Asymptotic Distribution of Maximum value**

$$F_X^*(x) = 1 - F_X(x)$$

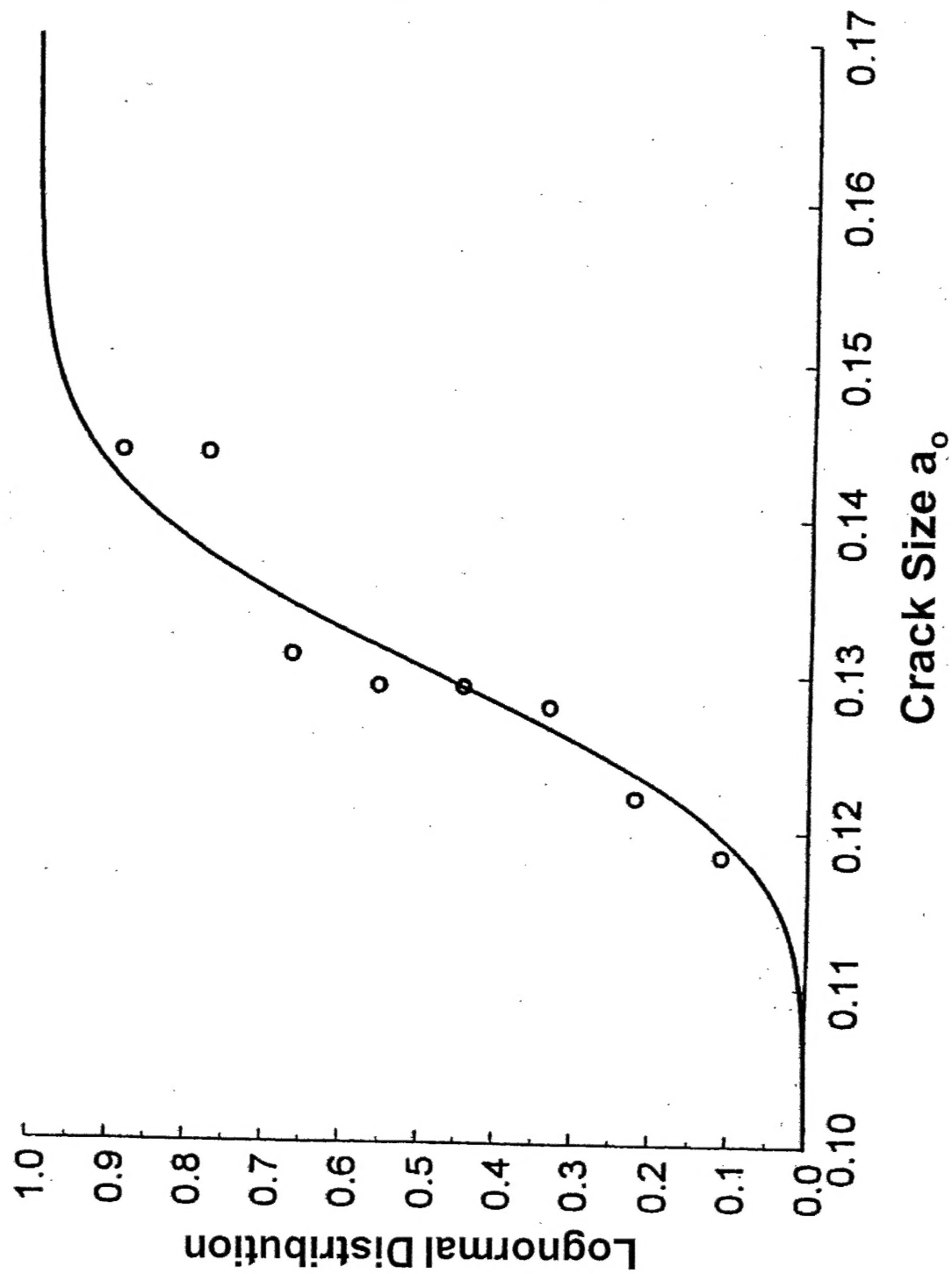
**Exceedance Curve.**

# Normal Distribution Plot for $a_o$

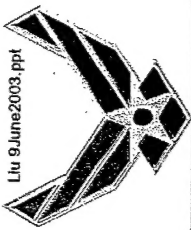




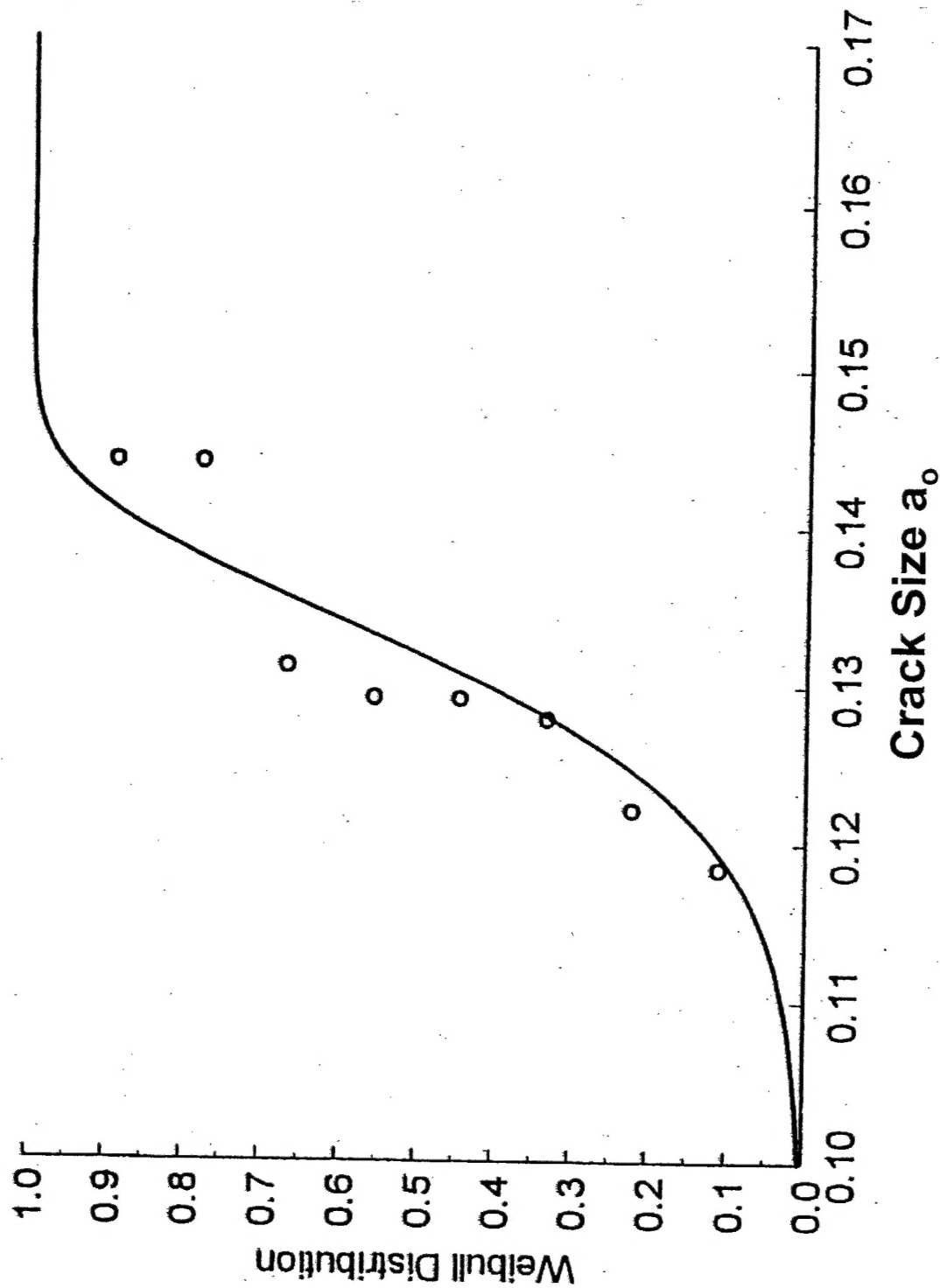
# Lognormal Distribution Plot for $a_o$

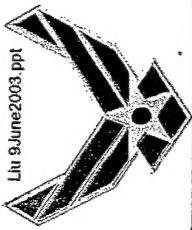






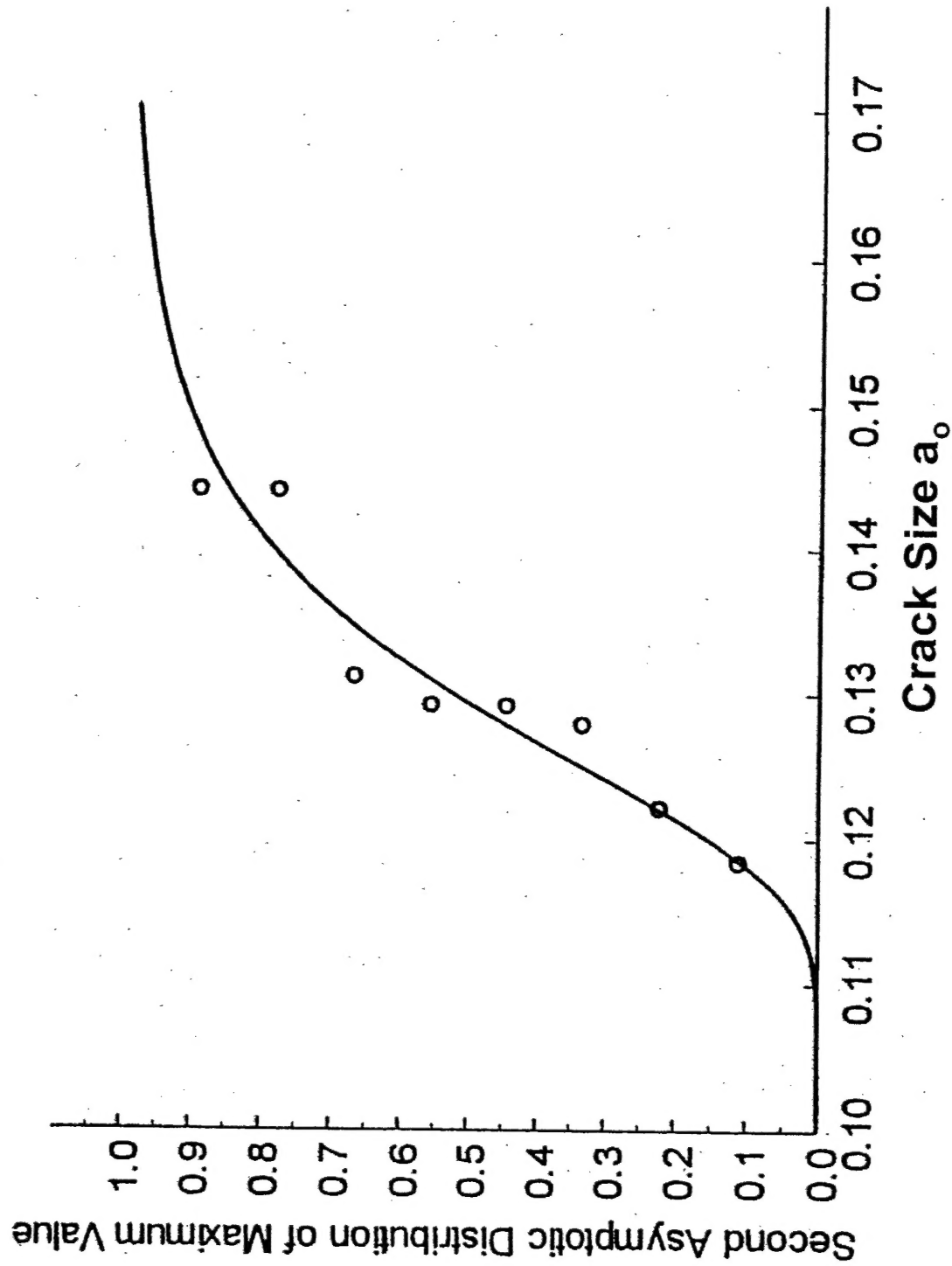
# Weibull Distribution Plot for $a_o$





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# Second Asymptotic Distribution Plot for $a_o$

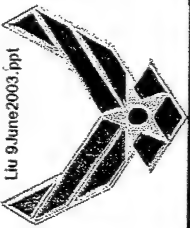


# Distribution Parameters for Normal, Lognormal, Weibull and Asymptotic Distributions



Strain Rate = 0.04 min<sup>-1</sup>

	$a_0$	$a^*$	$a_c$
$u$	0.1308	0.1344	0.1462
$\sigma$	0.0092	0.0090	0.0079
$u^*$	-2.037	-2.0092	-1.9242
$\sigma^*$	0.07021	0.06692	0.053961
$\alpha$	17.5546	18.4513	23.0450
$\beta$	0.1348	0.1383	0.1497
$k$	13.2524	13.8081	17.1205
$\nu$	0.1258	0.1295	0.1419



# Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions

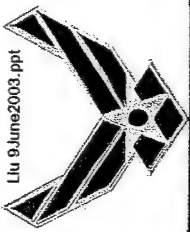


Strain Rate = 0.727 min. <sup>-1</sup>			
Parameters	$a_c$	$a^*$	$a_0$
$\mu$	0.12999	0.12131	0.11865
$\sigma$	0.00152	0.00159	0.00157
$\mu^*$	-2.04037	-2.10951	-2.13163
$\sigma^*$	0.01172	0.01315	0.01324
$\alpha$	80.1416	74.4660	74.4279
$\beta$	0.1308	0.1221	0.1194
$\kappa$	72.4100	70.8130	71.9883
$\nu$	0.1291	0.1204	0.1178

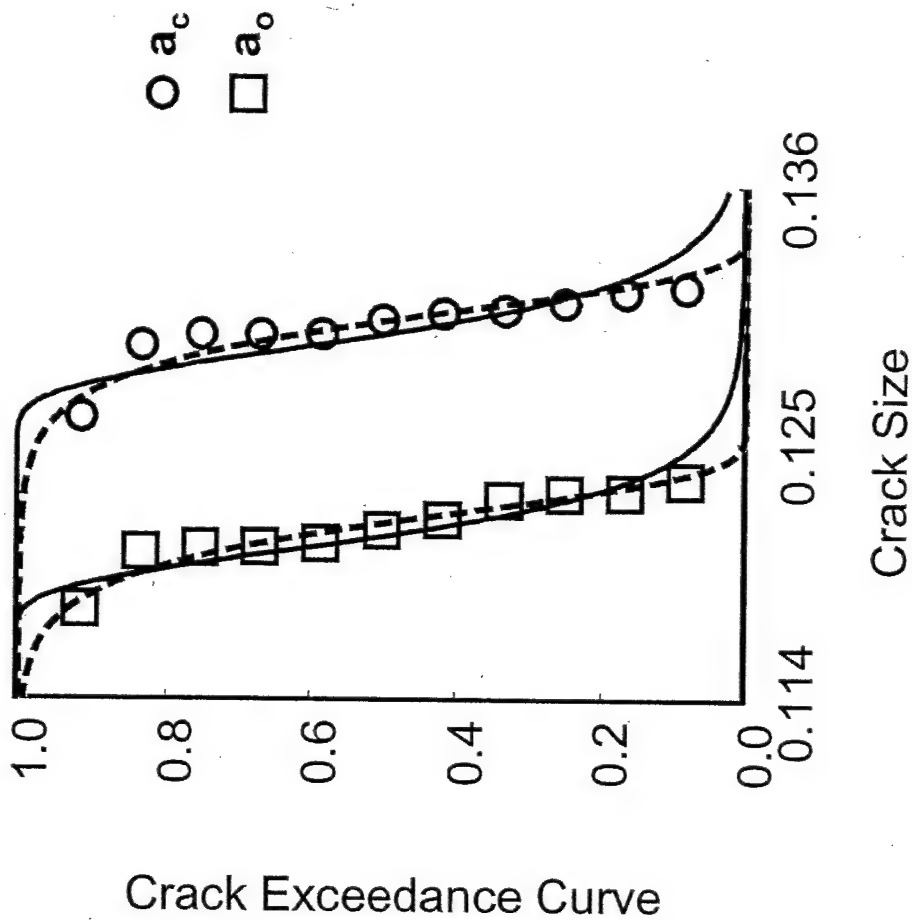
# Distribution Parameters for Normal, Lognormal, Weibull, and Asymptotic Distributions



Strain Rate = 18.182 min. <sup>-1</sup>			
Parameters	$a_c$	$a^*$	$a_o$
$\mu$	0.15750	0.14735	0.14597
$\sigma$	0.00290	0.00296	0.00290
$\mu^*$	-1.84847	-1.91517	-1.92456
$\sigma^*$	0.01842	0.02008	0.01989
$\alpha$	53.6601	49.5994	50.0668
$\beta$	0.1590	0.1488	0.1474
$\kappa$	51.3708	47.7906	48.4144
$\nu$	0.1559	0.1458	0.1444



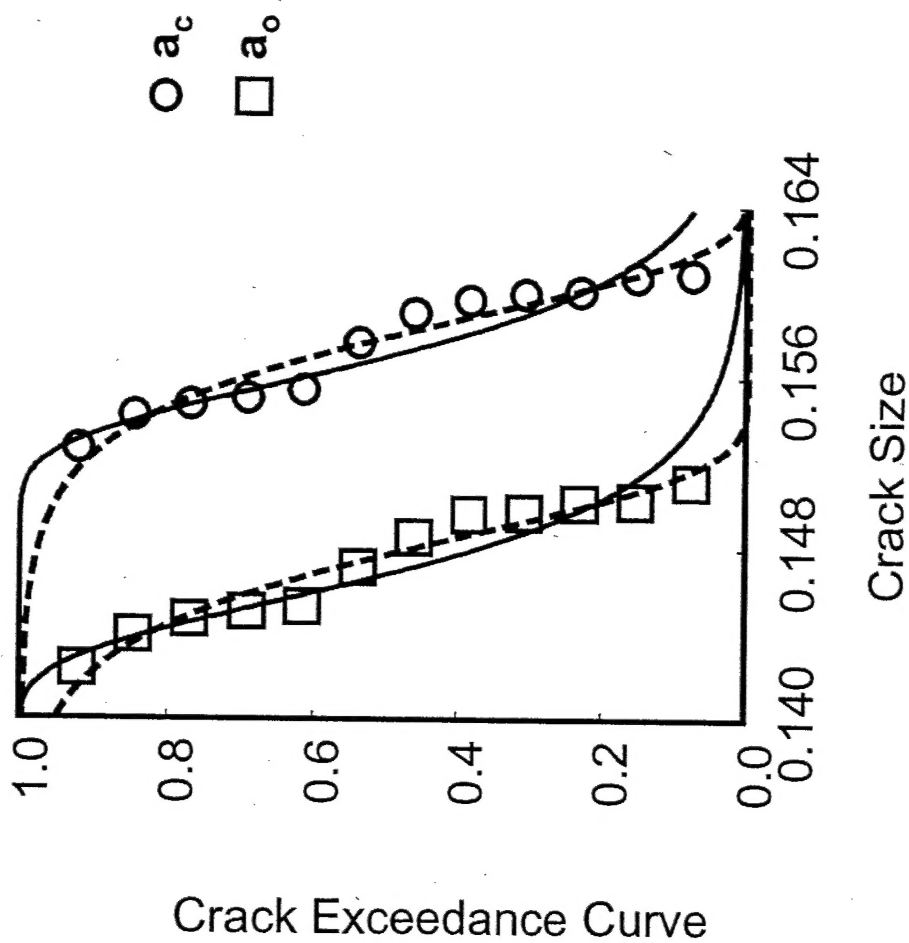
# Crack Exceedance Curves for Strain Rate = $0.727 \text{ min}^{-1}$



Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.



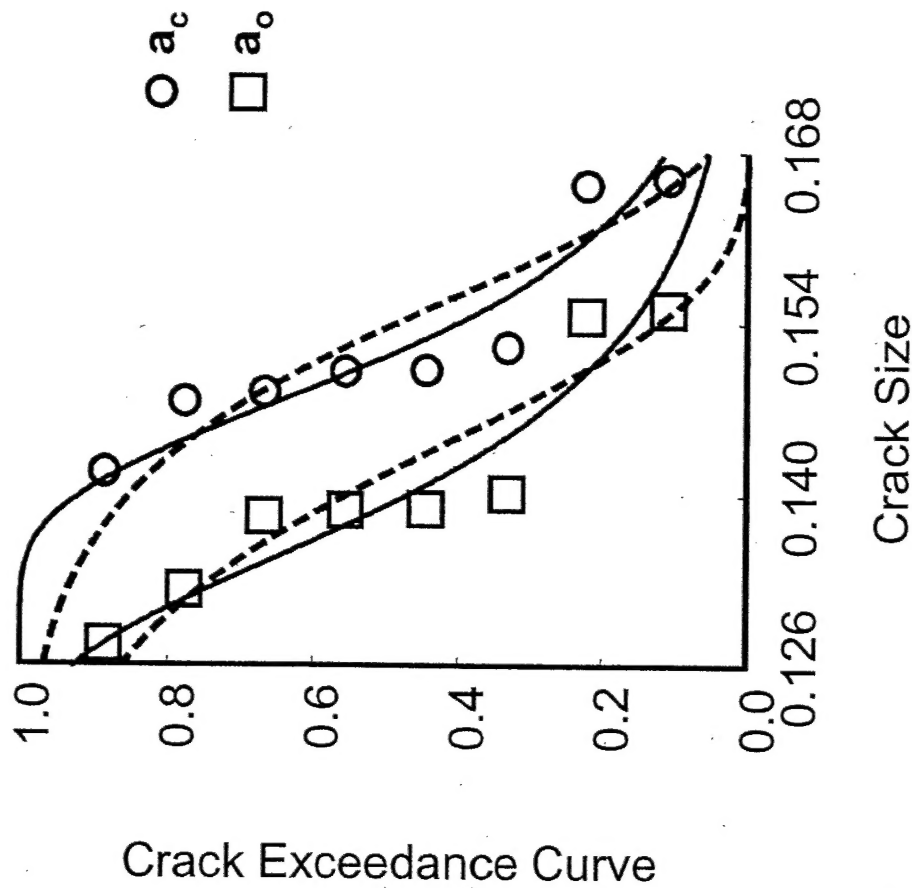
# Crack Exceedance Curves for Strain Rate = $18.182 \text{ min.}^{-1}$



Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

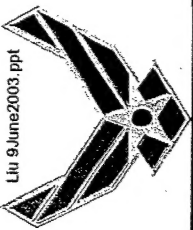


# Crack Exceedance Curves for Strain Rate = 0.04min.<sup>-1</sup>

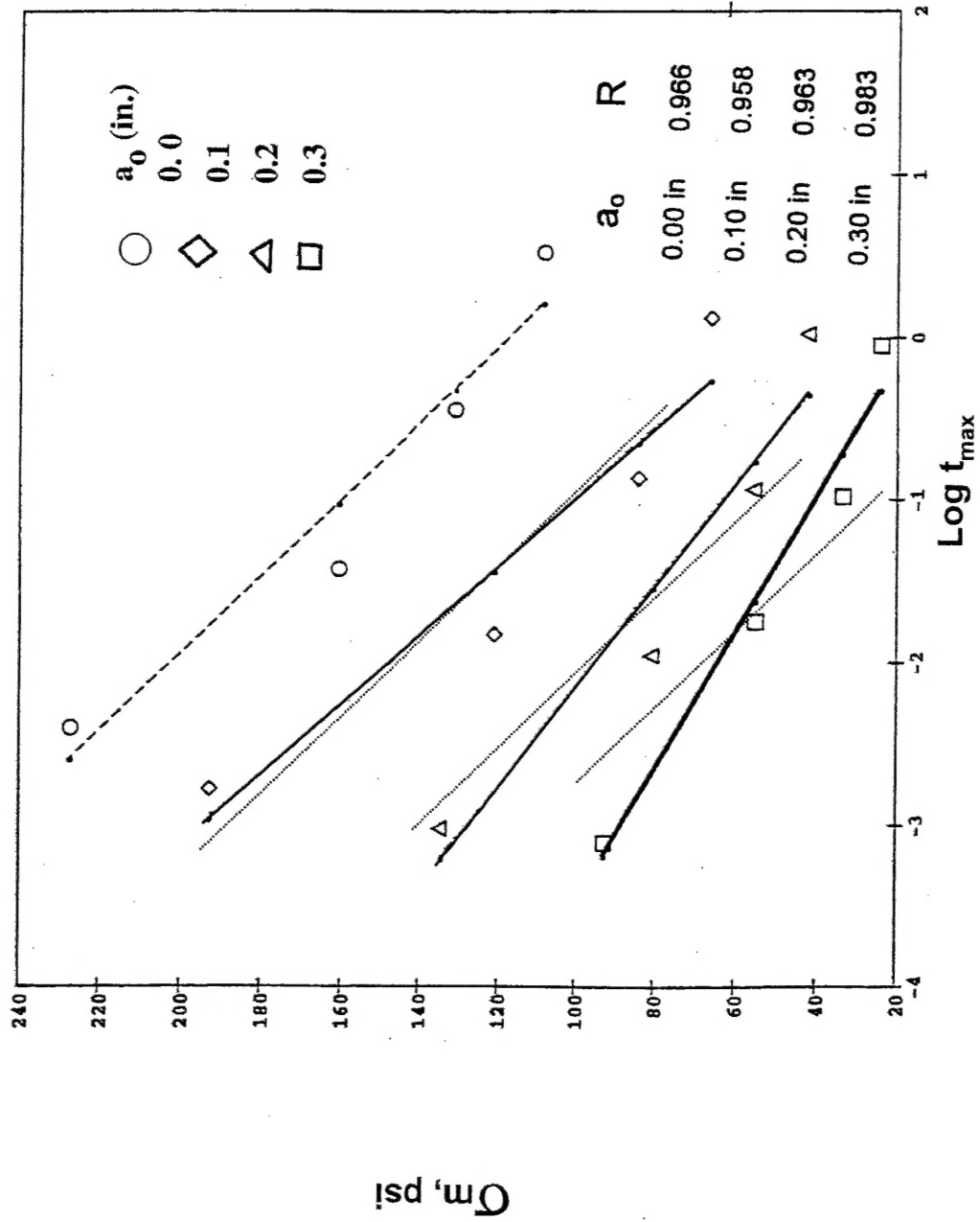


Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

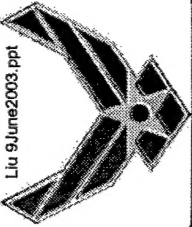




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Maximum Stress Vs Maximum Time



# Conclusions:



- For the material studied, the estimate inherent critical crack size,  $a_o$ , is insensitive to the strain rate and the averaged value of  $a_o$  is 0.132 in., which compares well with experimental value.
- The inherent critical crack size follows the second asymptotic distribution of the maximum value.
- The estimated  $a_o$  should be used to develop the inspection criterion.